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OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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Observing Mars with a Small Telescope	*A. F. Miller*	191
The Determination of Stellar Distacens	*Sir F. W. Dyson*	195
The Deviations of Falling Bodies	*J. W. Campbell*	202
The Orbit of Boss 1082	*J. B. Cannon*	210
Astronomy in April	*A. R. Hassard*	214
Observatories in Canada	*Otto Klotz*	217
Distances of Two Star Clusters	*W. H. Pickering*	225
Meetings of the Society		
At Toronto	*A. F. H.*	229
Review of Publications	*C. A. Chant*	232
Notes from the Meteorological Service		
Report of the Weather in Canada, March, 1918	*Sir F. S.*	234
Magnetic Observations, February, 1918	*W. E. W. J.*	236
Earthquake Records at Toronto and Victoria, B.C., March, 1918	*J. Y.*	237
Astronomical Notes		
Aurora Borealis		238
Planetary Perturbations and Æther-Drift		239
Hypothesis to Account for the Spectral Conditions of the Stars		239
Why the Atmosphere Generally is Unsaturated		240
The Nebula N.G.C. 1068 (M 77)		241
The Mandeville Station	*J. R. C.*	242
Notes and Queries		
Reforms in Time-Keeping		243
Unification of Civil and Astronomical Time		245
Information Regarding Small Planets		248
Aurora of April 5, 1918		248
Assistant Chief Astronomer		249
The 72 inch Mirror Completed		249
What is a "Siderail" Clock	*C. A. C.*	250

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PLATE III.

FIG. 1. MARCH 20, 9.30 P.M.

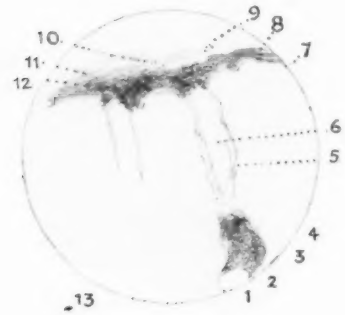
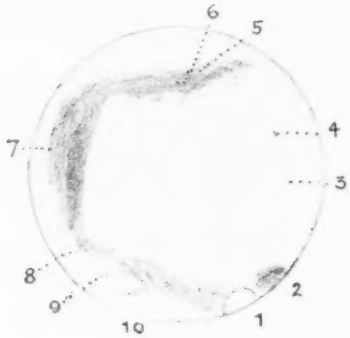
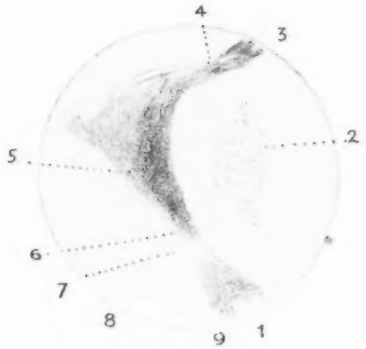


FIG. 2. MARCH 22, 9.15 P.M.





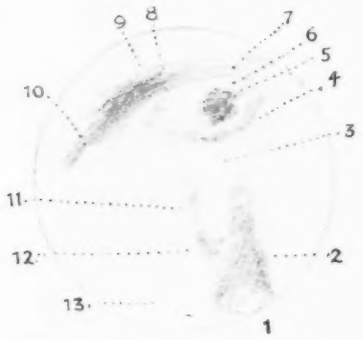


FIG. 3. MARCH 24, 9 P.M.

FIG. 4. MARCH 29, 9.30 P.M.

Drawings of Mars by A. F. Miller, Toronto, using a 4-inch Wray Refractor, Power 300.

KEY TO OBJECTS ON THE DRAWINGS

FIG. 1	FIG. 2	FIG. 3	FIG. 4
1 North polar cap	1 North Polar cap	1 North polar cap	1 North polar cap
2 Mare Acidalium	2 Mare Acidalium	2 Indistinct shadings in Eden and Arabia	2 Ceraunius
3 Baltia	3 Eden	3 Sinus Sabæus	3 Tharsis
4 Tempe	4 Edom	4 Solis Pons	4 Tithonius Lacus
5 Hydaspes	5 Sinus Sabæus	5 Syrtis Major	5 Solis Lacus
6 Indus	6 Deucalionis Regio	6 Osiridis Prom.	6 Thaumasia
7 Aromatum Promontory	7 Syrtis Major	7 Nili Pons	7 Aonius Sinus
8 Auroræ Sinus	8 Osiridis Prom.	8 White region	8 Bosphorus Gemmatus
9 Margaritifer Sinus	9 Nili Pons	9 Neith Regio	9 Auroræ Sinus
10 Deucalionis Regio	10 White region		10 Ophir
11 Fastigium Aryn			11 Ganges
12 Sinus Sabæus			12 Lunæ Lacus
13 White Region			13 Tempe

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OBSERVING MARS WITH A SMALL TELESCOPE

BY A. F. MILLER

AFTER each recent opposition of Mars we have read of so many marvels seen by skilled observers using powerful instruments under exceptionally favorable conditions, that the amateur possessing only a small telescope is apt to conclude it can reveal nothing of interest or value; therefore he allows the favorable opportunity of an opposition to pass unutilised, at most taking but a few casual looks at the planet, which, because of its position in our system, and still more because of its resemblance in several respects to the earth, our own abode, is admitted by most astronomers to be more worthy of careful study than perhaps any other member of the sun's family. There is however no reason why the owner of any good telescope of three inches aperture or upward, (or even a smaller one if of fine quality), should not turn it to account for Martian study, and if he will but do so diligently, frequently and carefully, he will soon find the work deeply interesting, and his acquaintance with the planet's surface so enlarged that ere long its main features will become to him familiar as an oft-studied map. Without attempting to enter into details of the strange landscapes the

telescope reveals to the student of areography, I will endeavor to state as briefly as possible the methods of observation which my rather long experience enables me to recommend as leading with certainty to the best results attainable with a moderate or small aperture.

And first let me say that although to the unaided eye Mars generally appears less brilliant than Jupiter, its surface is really much brighter, for which reason it bears a higher magnifying power under proper conditions of seeing. Therefore a rule may be laid down *that the highest power permissible by the quality of the instrument and the state of the atmosphere will generally give the best visual results.* In focussing the utmost care should be taken, and it will be found best to finally adjust the focus on the surface markings rather than on the planet's limb which is sometimes hazy owing to conditions existing in the Martian atmosphere, though details near the centre of the disc are clearly discernible.

Following the sage advice of good old Captain Cuttle, the observer should "make a note of" all features seen. The best records for the amateur are *sketches* made at the telescope, supplemented by notes as to the general aspect, colors, intensities and so forth of the surface markings. He will simplify his work by having ready beforehand paper on which circles have been traced, in which the details may be inserted, beginning with the most obvious features located as nearly in their proper positions as the observer's skill will permit, the fainter details being subsequently added, and the resulting sketch frequently compared with the image seen in the telescope. A good way is, to make several successive drawings at intervals of a few minutes, and combine the general results in a final drawing which will show everything seen by the observer at that time. The date and hour should be appended to each sketch. After completing his drawing he ought, if possible, to compare it with a good chart of Mars so as to identify the region he has had under observation. He may *then* quite fairly study the finer details of the chart, and fixing some of them in his mind, return to the telescope and see whether he cannot detect them on the planet; if successful, adding them to

what he has already drawn. As to the size of the sketches, if the observer should find his circles show a considerable amount of space void of detail, he may reasonably conclude his drawing was made on too large a scale and a reduction of size would be beneficial ; of course, should he find his drawing crowded, the converse would hold good. But by all means he should seek to fill in *carefully*, giving to each marking its relative proper size, location and intensity so far as his skill and patience will permit. He should not be discouraged by failures at the outset, but bear in mind that only by practice can he attain to success.

In order to use high-power oculars effectively the observer should be seated comfortably at the telescope, for if standing or stooping in a cramped or strained posture he cannot work to the best advantage. When owing to the high altitude of the planet the head must be bent backward to reach the ocular he should devise some sort of rest to support the shoulders and neck. The summer oppositions which occur when Mars is in the lower part of the zodiac are seasons when observing can be done with great comfort as to bodily position, and then too its angular diameter being greatest, the visibility of fine details is much enhanced. These benfits are to some extent offset by the low altitude of the object which is detrimental to good seeing. However, that should not discourage the observer, as our summers afford many nights of admirable atmospheric conditions, and the Martian student must ever be on the watch to take advantage of such opportunities. At all seasons he will find *moments* during which he can glimpse details of extraordinary minuteness on the planet's surface. Unfortunately these glimpses last but a second or so, and all one can do is, to try to recollect as much as possible of the fleeting view, subsequently transferring it from memory to the drawing.

The observer ought to contrive some shelter from wind, should such prevail, while he is using his telescope with a high power. He should frequently rest the eye for a few minutes ; on returning to the ocular after such a little " recess " he often sees much better than before. In winter he should manage not

to be cold, which is, doubtless, more easily said than done; however adequate clothing and occasional resting spells, during which he betakes himself to a warm room, will generally suffice to prevent discomfort on cold nights.

A lamp is of course, needed for sketching. It may be of any kind suiting the observer's convenience. It should be placed on some sort of small stand supporting the drawing book, and an arrangement provided for cutting off the light except while the sketches are being made. A small electric lamp so contrived as to illuminate the paper only and controlled by a switch, is ideal under all conditions.

The student of Mars should realize that the minute details shown on a good chart of the planet have been discovered and mapped *gradually*, not even the most skilful observers using the best instruments under most favorable conditions seeing more than a few such features at any one time. He should endeavor to follow their example, sketching from night to night all his instrument will show, and later combining all his sketches into a general plan. If he will do this systematically and faithfully he will be surprised at the amount of detail he will ultimately record. He ought, by all means, to familiarize himself with the elegant classical or mythological nomenclature first introduced by Schiaparelli and since adopted and greatly extended by other great observers.

Lastly, the amateur should always bear in mind that one can never tell when a carefully made observation may prove of real scientific value and possibly lead to some important result. But should he never be so fortunate as to utilize his work in that way, he will surely find the careful study of Mars at once interesting and beneficial, tending alike to advance his knowledge and improve his observational skill.

TORONTO,
April, 1918

THE DETERMINATION OF STELLAR DISTANCES*

By Sir F. W. Dyson, Astronomer Royal

THE interests of astronomers are divided between the study of the solar system and the great universe of stars of which the solar system is a mere unit. There are numerous problems still unsolved connected with the sun and planets, which attract physicists and mathematicians as well as astronomers. In the main, however, the efforts of astronomers during the present century have been devoted to the extension of our knowledge of the stellar universe. Observations on a large scale have been made in many different directions. Measurements of parallax, spectroscopic classification, proper motions, velocities in the line of sight, photometry, color determinations, double stars and variable stars have been extensively investigated. These different researches have thrown light on one another, and have all contributed towards a true description of the present state of the stellar universe. In such a description the most important element is the distance of the stars from us. A knowledge of the distance is essential to a complete determination of the position, the velocity, the luminosity and the mass of a star. On the other hand our general knowledge of the velocities, luminosities and masses of stars can be used as guides to their distances.

From the time of Copernicus, astronomers have looked for an annual movement in the apparent positions of the stars due to the shifting position of the earth as it travels round the sun. This causes a star which is comparatively near to us to appear to describe an ellipse in the sky with reference to the background of more distant stars which are in the same direction as seen by us. The changes we see are small angular changes and provide a measure of the parallax or small angle subtended by the radius of the

*Reprinted from *Scientia* for June, 1917

earth's orbit at the distance of the star. The parallax of a star is thus the reciprocal of the distance,—a parallax of one second of arc (1″) implying a distance of 200,000 times the distance of the sun from the earth, 0″.5 double this distance and so on. With the progress of astronomy it has become possible to measure angles with continually increasing accuracy. The large photographic telescopes especially have contributed to this. It is possible now with a very few photographs to determine a parallax as small as 0″.05, or measure a distance 4 million times as great as that of the sun. Naturally, great care and special precautions must be taken both in obtaining photographs and in their measurement. The accuracy with which these angles can be measured may be put down as ± 0″.01, and considerable confidence can therefore be placed in measures of distance which are not more than 4 million times that of the sun, and even greater distances can be determined, though somewhat roughly.

Within a sphere of this radius, it should then be possible to locate all the stars which are sufficiently bright for observation. It is only necessary to know which to look for. For this the apparent movement of the star on the face of the sky forms a good guide. If stars of proper motion greater than 20″ a century be examined, about 1 in 5 are found to be within this limit of distance. Probably 800 stars may be ranged in this way, though up to the present the number known is under 100. It is important that the region of space around the sun should be thoroughly scrutinized. It provides us with information about all the individual stars and not merely the average results with which we have to be content in other cases.

Another method which has led to the determination of the distances of individual stars was published a few years ago by L. Boss. He found a loose collection of stars in the Hyades which were all apparently moving to one point in the sky. He interpreted this as meaning that these stars are actually moving in directions parallel to the line from the sun to this point of the sky. Further, the stars must all have the same velocity, or they would not remain in existence as a cluster. This velocity is determinable from spec-

troscopic observations of one of the stars, and when it is known, the angular motion of each star on the face of the sky can be used to find its distance. In this way the parallaxes of 40 stars ranging from 0″.021 to 0″.031 have been obtained. Other clusters of a similar character have been found. They give much food for thought, but are referred to here as contributing the number of individual stars whose distances are known.

Let us next consider a method which gives the average distances of stars, although not the distances of individual stars. It was pointed out by Herschel that the community of direction of the proper motions of stars, i. e. of their angular motion on the face of the sky, might be explained by a movement of the solar system towards a point in the sky not far from the bright star Vega. A large number of subsequent researches have established this firmly. Further, spectroscopic observations of velocities in the line of sight, especially at the Lick Observatory, have determined the velocity of the solar system as 19.5 kilometres a second. This movement carries the solar system in one century 410 times the distance of the earth from the sun. The outlook from the solar system is thus perceptibly changed in a century. If the stars themselves were stationary, the distances of thousands of them could easily be determined from the extremities of such a long base-line, but as they are all moving, this cannot be done. We may, however, take a group of stars and, on the assumption that the peculiar motions of the stars themselves are haphazard, may attribute the general movement of the group to this motion of the solar system in the opposite direction. This method has been applied to find the mean distances of stars of different magnitudes. For example, those of magnitude 6, i. e. those just visible to the naked eye, are found to have a mean parallax of 0″.012, corresponding to an average distance of 18 million times the sun's distance. As we proceed to groups of fainter stars, the average distance increases, due to the inclusion of more distant stars, but in the group of fainter stars there are many which are no more distant than the brighter ones, these stars appearing fainter because they are intrinsically less luminous. It is found in this way that stars which are 100 times

as faint as those just visible to us are not 10 times as far away, but only between 3 and 4 times the distance.

Instead of classifying the stars according to their magnitude or apparent brightness, the spectroscope enables them to be arranged according to their physical characteristics. If the spectra of different stars are compared, it is found, and it is an extremely remarkable fact, that they can be arranged in one continuous series. The lines in the various spectra may be due to helium or hydrogen, iron or titanium, but the chemical composition of the star is not the essential of the grouping; otherwise they would not fall, as they do, into one orderly sequence. Broadly speaking, the spectroscopic classification arranges the stars according to their temperature. It agrees with classification according to color, the blue stars being hotter than the sun, the yellow stars of nearly the same temperature, and the red stars cooler. When the proper motions of these different groups of stars are examined, those of solar type are found to be nearer to us than either the blue stars or the red stars of the same magnitude. In addition, spectroscopic measurements show that the peculiar motions are different for these different groups, particularly a group of stars at a very high temperature known in the Harvard classification as B stars and distinguished by the presence of lines due to helium in their spectra, have very small, peculiar velocities. Their proper motions are thus mainly due to the movement of the solar system. If then we assume that they are wholly due to this, their distances can be obtained. On this principle, or somewhat similar ones, the distances of these stars have been determined by Kapteyn, Plummer and Charlier.

So far we have utilized the apparent movements of the stars as the key to their distances. There are, however, two other methods which can be employed. The first is of somewhat limited application, and depends on the fact, brought out by Russell, Ludendorff and others, that there is no great range in the masses of stars. This is determined from double stars whose distances are known and from stars which spectroscopic observation shows to be double. The mass of a double star is measured by the pull

between its components. This pull is by Kepler's third law determined by the distance apart of the two stars and the time they take to complete a revolution about one another. If there is a double star at an unknown distance, and we may assume that its mass is, let us say, twice that of the sun, we may infer from the period of revolution what is the distance apart of the two components. Comparison with the angular distance apart, found by discussion of double star observations, gives the distance of the star from us. The distance of the stars from one another depends on the cube root of the mass, so that so great a charge as an eight fold increase in the mass will only imply a two fold increase in the distance. This method is being developed in more detail as our knowledge of the actual masses of double stars of different types of spectra increases.

Methods of much wider application depend on our knowledge of the intrinsic luminosity of the stars. If we could say that a star would be equal in brightness to the sun when at the same distance from us we could infer at once its distance. This method was proposed by Huyghens and Lambert.* It cannot be applied in this crude manner because there are very great differences in luminosities among the stars: some, such as Canopus, give out more than a thousand times as much light as the sun, and a little star recently discovered by Barnard has only one three-thousandth part of the sun's luminosity. But there are types of stars in which there is not a great range of luminosity; for example, the B stars already referred to do not seem to have a great range. They are all very brilliant, say a hundred times as brilliant as the sun on the average, and they do not differ widely among themselves. Though some may be 3 times as bright as the mean and others only one-third as bright, half the stars will be found to be between these limits. In this manner Charlier has calculated the distances and positions of all the B stars. He finds that they form a spheroidal group with its short axis perpendicular to the plane of the milky way and one-third of the equatorial axis. The position of the centre of the group relative to the sun is also determined.

* Plummer, "The Observatory," 1916, p. 16.

It is probable that this method may be extended to other groups of stars. The researches of Russell and Hertzprung have shown that the red stars may be divided into two groups, "giants" and "dwarfs," which are clearly separated. The "giant" red stars are of great luminosity, like the B stars, and there is not a very great range among them. The apparent magnitude should therefore be a very good measure of the distances of the class of stars and as they are many of them at such great distances that their movements, even in a century, are very small, will afford the most available and accurate means of finding their range.

A more subtle method of utilizing the light of the stars to determine their distances has recently been devised by Adams. Although the spectra of the stars do fall into one unbroken line dependent on their temperature, there are small differences with respect to particular lines which he has discovered and examined. We know that changes in spectra are produced by differences of pressure. It is therefore not surprising that differences may be detected between the spectra of a large and a small star which are at the same temperature. Differences in the force of gravity and the density of the part of a star near its surface, from which light reaches us, and which we analyze in the spectroscope, are to be anticipated. Adams has found marked differences between the relative intensities of certain lines in stars which are similar in spectral type and apparent magnitude, but which are known to be at widely different distances from us. He has taken the stars which are known to have parallaxes greater than 0″.05 and compared their spectra with those of stars known to be at very much greater distances, but which appear to us to be equally bright. The latter stars are much more luminous than the former. His measurements of relative intensity are found to give a reliable estimate of the luminosity, and from the luminosities the distances are readily inferred. For example, if there are two stars of equal apparent magnitude, and the first is known to be nine times as luminous as the second, then its distance must be three times as great as that of the second. It seems likely that this method will be extensively

developed and will add very materially to our knowledge of the distances of stars.

A very striking application of the peculiarities of the light from certain stars has been made by Hertzprung to determine the distance of the smaller Magellanic cloud. Miss Leavitt, of Harvard College Observatory, had shown from the study of variable stars in clusters that for a certain peculiar class of variables known as Cepheids there existed a relationship between the period of variability and the apparent magnitude of the star. As the stars in the same cluster may all be regarded as at the same distance from us, it follows that there is a relationship between the period of variability and the luminosity of a Cepheid variable. The necessary constant of the formula was inferred from a consideration of a number of the nearer Cepheid stars, whose mean distance could be derived from the solar motion. From this mean distance, combined with the observed magnitudes, the absolute brightness of Cepheids of different periods was derived. Now the smaller Magellanic cloud contains a number of Cepheid variables which are very faint on account of their great distance. From the period of their variability, combined with their apparent magnitude, the smaller Magellanic cloud was found to have a parallax of 0″.0003.

I have attempted to show in what unexpected ways our knowledge of the distances of the stars is being extended. We rely on accurate determinations of parallax to furnish distances, which are wholly independent of the luminosity and physical characteristics of the stars. These are extended statistically by the combination of the study of proper motions and of the velocities of stars to or from us determined by the spectroscope. We are thus enabled to discover the relation between the luminosities of stars and their physical characteristics indicated by their light and its analysis. These characteristics are then applied to determine the distances of stars which are too far away for their movements to be appreciable. It is to the correlation of widely different researches that recent progress is due.

GREENWICH, ROYAL OBSERVATORY.

THE DEVIATIONS OF FALLING BODIES.

BY J. W. CAMPBELL.

1. HISTORICAL SUMMARY.

THE history of the problem of the Deviations of Falling Bodies dates from the time of Newton. Investigations have been made, both experimentally and analytically. All investigators have agreed that there is an easterly deviation from the plumb-line suspended from the initial position of the falling body, but there has not been the same harmony of results regarding the meridional deviation. Some investigators have found no meridional deviation, one has found a poleward deviation, while the majority have found an equatorward deviation. It is possibly because of this lack of agreement that so much attention has been given to meridional deviation.

Analytical results are much more trustworthy than those derived from experiments. The mathematical solution gives the result when the body falls subject to the influence of gravity only, while in conducting experiments it is almost impossible to eliminate the disturbing effects of local air currents, etc. The meridional deviation is small in any case, and so it is not to be wondered at that these irregular disturbances rob experimental results of much of their reliability. The mean of a large number of observations must be taken, and even then Professor Hall, of Harvard, found that the mean deviation he obtained was very little greater than the probable error of his results. But in spite of irregularities the fact remains that almost all men who have conducted experiments have obtained an equatorward deviation as their mean result.

For a complete review of the experimental work done on the problem, the reader is referred to an account given by Hall in the *Physical Review*, vol. xvii. The summary of the results there given is as follows:*

The confliction of analytical results seems to arise from the

Name	Date	Place	h	S.D.*
Hooke	1680	London	8·2 m	+ ve
Guglielmini	1791	Bologna	79·3 m	1·19 cm.
Benzenberg	1802	Hamburg	76·3 m	0·34 cm.
Benzenberg	1804	Schlesbusch	84·4 m	0·0 cm.
Reich	1831	Freiburg	158·5 m	0·44 cm.
Rundell	1848	Cornwall	400·0 m	25-50 cm.
Hall	1902	Cambridge	23·0 m	0·005 cm.

*As all these experiments were performed in the northern hemisphere the equatorward deviation is southerly and is marked "S.D."—southerly deviation.

different assumptions which mathematicians have made regarding the earth's gravitional field. Most modern writers have assumed, either actually or virtually, a symmetric distribution of revolution for the earth, but Professor Roever in his later papers has obtained results without this assumption. His formulae give the meridional deviation due to changes in gravity which the particular features of a given locality will produce, and his results show that it is possible that local conditions may be such as to give a poleward deviation, but that this is the exception.

A full account of the early history of the mathematical work done is given by Dr. R. S. Woodward in *Science*, 1913, but since then several more papers have appeared. Gauss's work is given in Vol. V. of his *Werke* (1803), and Laplace's solution appears in Chap. V., Book X. of his *Collected Works*. Of recent writers, Roever has published four papers; the first two are given in Vols. XII. and XIII. of the *Transactions of the American Mathematical Society*, the third in Vol. XXVIII. of the *Astronomical Journal*, and the fourth in Vol. III., Pt. 1., No. 2. of the *Washington University Studies*. Woodward published a paper in Vol. XXVIII. of the *Astronomical Journal*, and a treatment by Professor F. R. Moulton appears in the *Annals of Mathematics*, 2nd Series, Vol. XVII.

Of the earlier writers, Gauss found an equatorward deviation, Laplace found no deviation. Of the later writers, all except Woodward found an equatorward deviation several times that ob-

tained by Gauss, while Woodward obtained a poleward deviation. But Roever in his third paper has shown the fallacies by which Woodward got a result contrary to the other writers.

2. GEOMETRICAL PROOF OF AN EQUATORWARD DEVIATION.

If we assume a symmetric distribution of revolution for the earth, a simple geometrical proof of equatorward deviation can be given. The proof establishes the *direction*, though not the *amount*, of the deviation, and to obtain the amount recourse must be had to analytical methods.

To begin with, let us consider the forces acting on a body suspended at a point P (fig. 1) above the earth's surface. The body is attracted, due to the earth's gravity, by a force which may

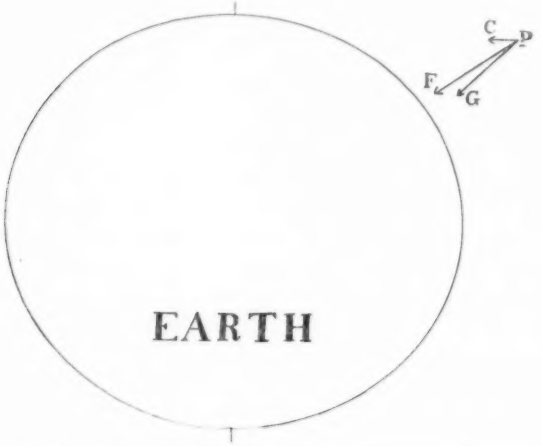


FIG. 1.—FORCES ACTING ON A SUSPENDED BODY

be represented by the vector PF. Now while suspended at P, the body will move with uniform speed along a circle whose centre is on the earth's axis. To produce this circular motion, a centripetal force PC is necessary, and it must be supplied at the expense of gravity. By vector subtraction the remaining component of PF is PG, and this component PG measures the weight of the body.

The weight PG and the earth's gravity PF are obtainable for any point P from two functions W and V, called the weight function and the Newtonian potential function, respectively. These two functions are connected by the equation

$$W = \tfrac{1}{2}\,\omega^2 r^2 + V,$$

where ω is the angular velocity of the earth's rotation and r is the distance of P from the earth's axis. *Level surfaces* for weight are therefore given by the equation

$$\tfrac{1}{2}\,\omega^2 r^2 + V = \text{const.}$$

Several of these level surfaces are shown in Fig. 2, S being the surface of the earth itself. It will be noticed that the level surfaces become more oblate the farther they are from the earth.

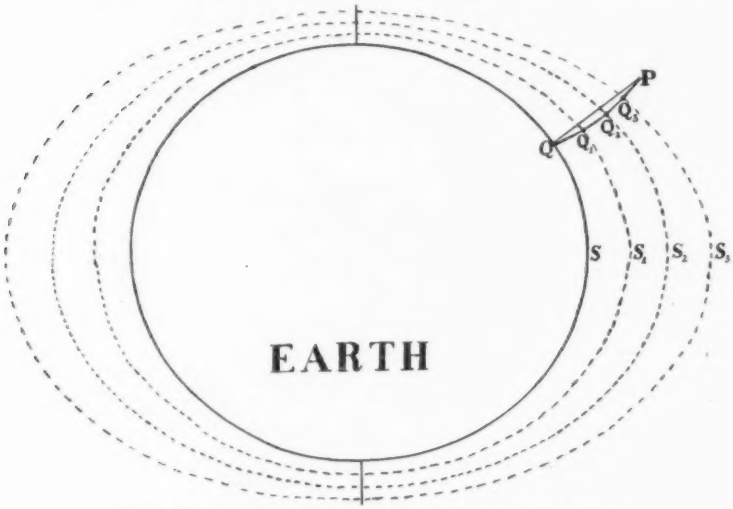


FIG. 2.—LEVEL SURFACES ABOUT THE EARTH, IN THE WEIGHT FIELD

These level surfaces have the property that the direction of a body's weight is always normal to the level surface passing through the body. If a plumb-bob is suspended from a point P (fig. 2), the plumb-line gives the direction of weight of the plumb-bob, and

hence the plumb-line is always normal to the level surface through the plumb-bob. Therefore if plumb-bobs be suspended at various distances from P, then the plumb-bob locus is concave towards the pole, as shown in Fig. 2, and the tangent to this locus at P is the direction of weight at P.

Let us now consider the motion of a particle on a circular cone (fig. 3). Suppose a particle of mass m moves along a spiral path C which lies in a circular conical surface. Then at any point P its motion may be resolved into two components, one along the cone-circle A through P, and the other along the generating line L

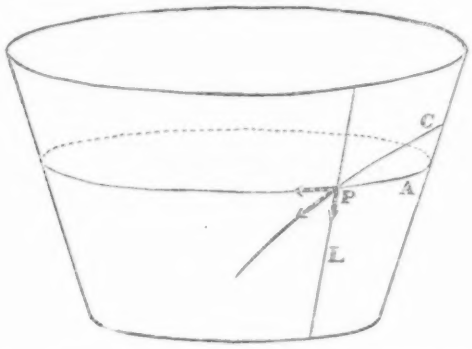


FIG. 3.—MOTION OF A PARTICLE ON A CIRCULAR CONE.

through P. If we further suppose that the motion along A is of uniform speed v, then it requires for its production a centripetal force of magnitude mv^2/r, where r is the radius of A. If the motion along L is accelerated, a force will be necessary to produce the acceleration. Variation in this latter force would alter the "steepness" of the path C, but the path would still lie in the cone surface. Therefore *a spiral motion on a conical surface, with uniform speed v along the cone circles at every point, is produced in a particle of mass m by a centripetal force of mv^2/r, where r is the radius of the cone-circle through m, and by an arbitrary force acting along the generating line through m.*

Now if we have a plumb-line PQ suspended from a point P (fig. 4), this plumb-line will trace out a circular conical surface as the earth rotates, which surface might be designated as the *plumb-line cone* through P. Further, if a body of mass m is suspended at P, then, as shown in Fig. 1, it is under the influence of the centripetal force PC and its weight PG, these forces being the components of the earth's gravitational attraction. Now if when m were allowed to fall the forces acting on it always fulfilled the conditions of the proposition stated above, then its motion

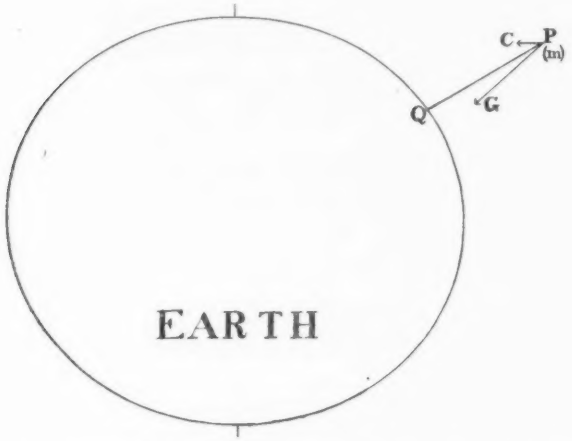


FIG. 4.—ACTION OF ROTATING EARTH ON A FALLING BODY.

would be in the plumb-line cone through P, its point of impact on the earth would have the same latitude as Q, and there would therefore be no meridional deviation. But the weight PG does not act along PQ, as was shown by Fig. 2. The centripetal force PC and the component of PG along PQ would cause m to begin to move in the plumb-line cone, but the component of PG normal to PQ would disturb this motion and give a resultant motion outwards from the cone. The effect of the forces acting on m at any subsequent point P' during its fall might be similarly considered.

and it could be shown that the effect would be motion outward from the plumb-line cone through P'. Therefore *a falling body will continually deviate equatorward during its fall.*

The foregoing proof is based on the supposition that the earth is a figure of revolution, which was virtually the assumption of Woodward and Moulton. The figures and method of reasoning may also be used to account for the results of Gauss and Laplace. Neither of these writers used potential functions, and the assumption which they made in common was that the weight of a body is constant in direction. Thus, according to them, the plumb-bob locus in Fig. 2 would be the straight line PQ, and therefore the weight of m (fig. 4) would act along PQ. One might imagine that if this were true the mass m would move in the plumb-line cone through P during its fall and not deviate meridionally, but such is not the case.

Since the forces PC and PG always act normal to the cone circle through m, the motion of m along the cone circles will be of uniform speed v, say. But

$$v = \omega r$$

where r is the radius of the cone circle and where ω is the angular velocity of m on it, and since as m falls r decreases, then ω must correspondingly increase. Let ω_0 be the angular velocity of the earth, and let $\omega = \omega_0 (1+k)$ be the angular velocity of m at some point P' during its fall, k being a positive quantity. Then the centripetal force required at P' to give motion on the plumb-line cone is

$$m v^2/r = m \omega^2 r = m \omega_0^2 (1 + k)^2 r.$$

But if the mass m were suspended at P', the centripetal force required to make it revolve with the earth would be $m \omega_0^2 r$.

Now, according to Gauss, when the earth's attraction on m is decreased by the centripetal force $m \omega_0^2 r$, the remainder, its weight, always acts along the plumb-line $P'Q'$. Therefore, if the attraction were decreased by the centripetal force $m \omega_0^2 (1+k)^2 r$, the remaining component would be inclined to $P'Q'$ in the same

manner as PG is inclined to PQ (fig. 4). This shows why Gauss's assumption, as stated above, gives an equatorward deviation instead of no deviation, as it might have been expected to give.

In Laplace's paper, however, not only is the constancy of the direction of weight assumed, but some terms in the equations of the second order in the earth's rotation are disregarded. These rejected terms, together with one or two other minor assumptions, must have been sufficient to offset the required increase in the centripetal force. In that case the mass m would move during its fall in the plumb-line cone through P, and there would therefore be no meridional deviation.

TORONTO,
February 26, 1918.

THE ORBIT OF BOSS 1082.

BY J. B. CANNON.

BOSS 1082 (α = 4h. 33m., δ = +52° 54′, mag. 5.3, type G5.) was found to be a spectroscopic binary at Mt. Wilson.

Three plates taken there in 1914 and 1915 gave velocities of —38, —66 and 0 km. Forty-two plates were taken here in 1916, 1917 and 1918, and from these the following orbit was obtained.

The Mt. Wilson observations follow. They lie on an average about 6 km. more positive than our observations, and if this amount be subtracted from each observation, they fit the curve fairly well.

MT. WILSON OBSERVATIONS.

Date	Julian Day	Phase	Velocity	Residual
1914, Dec. 2.820	2420469.820	58.27	—38 km.	+ 6 km.
Dec. 24.786	491.786	80.24	—66	+ 1.2
1915, Mar. 2.646	559.646	27.10	0	+12.2

The lines used are given in the table below, the wave-length being found by means of corrections obtained from the line-residual in each plate.

4571.970	4415.316	4325.809	4271.775
4549.796	4404.956	4314.919	4233.331
4523.099	4352.165	4294.615	4215.808
4501.794	4340.734	4289.815	4143.776

The observations are as follows:

OTTAWA OBSERVATIONS.

Plate	Julian Day	Phase	Velocity	Residual
7819	2,421,132.81	116.26	—38.5	+1.5
7833	138.85	1.30	—23.9	+7.4
7852	141.82	4.27	—19.2	+8.3
7861	143.81	6.25	—33.1	—8.7
7874	148.81	11.25	—21.9	—1.8
7894	173.87	36.32	—15.5	+1.5
7901	182.76	45.21	—25.0	+1.3
7907	188.76	51.21	—41.3	—7.3
7917	190.63	53.08	—35.2	+1.7
7968	227.56	90.01	—61.4	+6.6
7992	244.55	107.00	—49.0	+4.4
8005	248.51	110.96	—44.8	+3.4
8008	251.51	113.96	—40.8	+2.3
8018	259.64	1.09	—40.3	—9.1
8033	262.60	4.05	—31.0	—3.0
8068	281.57	23.02	—17.0	—4.8
8075	287.62	29.07	—12.8	+0.1
8088	290.52	31.97	—12.1	+1.9
8103	297.57	39.02	—20.5	—1.2
8107	300.58	42.03	—21.2	+0.8
8115	304.58	46.02	—31.2	—4.9
8118	307.58	49.03	—24.8	+6.4
8131	317.59	59.04	—47.1	—2.0
8328	527.86	27.31	—12.0	+0.1
8332	537.84	37.29	—18.7	—1.3
8340	540.84	40.29	—23.4	—2.8
8350	545.83	45.28	—31.2	—4.9
8358	547.77	47.22	—32.9	—3.9
8366	559.84	59.29	—45.7	—0.3
8369	562.69	62.14	—41.8	+7.7
8371	565.62	65.07	—56.6	—3.5
8377	569.78	69.23	—58.9	—0.5
8380	574.51	74.06	—59.7	+3.2
8389	588.60	88.05	—74.3	—5.9
8403	593.61	93.06	—72.1	—5.2
8406	597.58	97.03	—65.6	—1.2
8432	618.54	117.99	—33.0	—4.6
8434	621.67	0.12	—41.9	—9.0
8440	633.59	12.04	—18.3	0.0
8441	635.63	14.08	—16.9	—0.4
8444	642.62	21.07	—10.2	+2.1
8455	646.53	24.98	— 4.5	+7.6

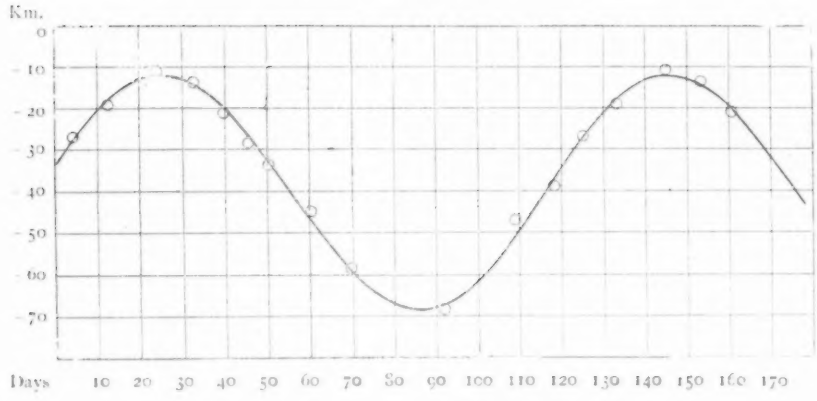
These observations were grouped into twelve normal places.

NORMAL PLACES.

No.	Julian Day	Phase	Velocity	Residua	Wt.
1	2,421,372.84	118.28	−38.9	−1.8	2
2	171.77	3.97	−26.8	+0.6	2
3	472.67	12.46	−19.0	−1.3	1
4	524.65	24.10	−10.9	+1.2	2
5	253.67	32.45	−13.5	+1.0	1
6	419.21	39.66	−20.9	−0.5	2
7	344.39	45.51	−28.3	−1.2	1
8	308.68	50.13	−33.5	−0.3	2
9	480.04	60.16	−44.9	+2.3	1
10	570.01	69.46	−58.4	+0.3	1
11	501.84	92.04	−68.3	−1.0	2
12	246.53	108.98	−46.9	+4.0	1

Preliminary values for the elements were found graphically.

$$P = 121 \text{ days}$$
$$e = \cdot 05$$
$$\omega = 280^\circ$$
$$K = 29 \text{ km.}$$
$$\gamma = -40{\cdot}35 \text{ km.}$$
$$T = \text{J.D. } 2{,}421{,}136{\cdot}05$$



RADIANT VELOCITY CURVE OF BOSS 1082

A least squares solution was carried through giving the following corrections :

$$\delta\gamma = - \cdot 12 \text{ km.}$$
$$\delta K = - \cdot 81 \text{ km.}$$
$$\delta e = - \cdot 031$$
$$\delta \omega = + 5°$$
$$\delta T = + 1 \cdot 5 \text{ days}$$

This gave the final values of the elements to which are appended the probable errors :

P	= 121 days	
K	= 28·19 km.	± 1·2 km.
e	= ·019	± ·042
ω	= 285°	± 42°·68
γ	= − 40·47 km.	± ·81 km.
T	= J.D. 2,421,137·55.	± 14·26 days.
$a \sin i$	= 46,900,000 km.	
$\frac{m_1^3 \sin^3 i}{(m_1 + m)^2}$	= ·28 × sun.	

Dominion Observatory,
Ottawa, Canada
March 25, 1918

ASTRONOMY IN APRIL.

BY A. R. HASSARD.

ON Friday night, April 5, 1918, a display of Aurora occurred which was one of the most brilliant and extensive I ever remember having seen. It commenced soon after darkness began, and was in full operation as late as midnight, when I ceased observing. I think about 9 o'clock saw the display at its greatest brilliance. An observer who was with me declared that the illumination was so bright as to cast a distinct shadow. I have spent some time in proving by actual experiment that the planet Venus is capable of casting a shadow, and think I might have demonstrated the same with the Aurora had I chosen to take the time. Occasionally the streamers shot up with marvellous rapidity, and the tongues were 60 and 70 degrees in length on many occasions. Whenever many streamers of light arose simultaneously, there was a parallelism in them which was most striking, for they did not seem to converge at the zenith, but poured out their soft, silent white splendor in broad and narrow ribbons that remained parallel with one another almost throughout their entire course. I was not able to see the horizon from my point of observation, but the streamers seemed to cover a range of perhaps 150° around the northern horizon and passed southward as far as the zenith, if not actually past it.

On the evenings of the 4th, 6th and 9th, I observed Mercury in the western heavens. The sun set at about 6.50 p.m., and the first view I had of the planet was between 7.17 and 8.15 p.m. On the 4th I viewed it until a few minutes after 8, at which time it was about 8° above the horizon. The planet was very pale, and nothing like as bright, I thought, as I have seen it on one or two other occasions. It also seemed to have the faintest tinge of red in it, due, perhaps, to the fact that the sky around it contained

some of the still living splendors of the vanished sun. Looking at it, however, through the telescope, its pearly whiteness was manifest, but the irradiation was so great as to prevent my being able to distinguish its phase, although perhaps a little more patience might have disclosed it.

On Friday evening, the 5th, I spent some time in examining, through my 9½-inch reflector, the planets Saturn and Mars. The ring is considerably inclined to the view at present, and as it is the north side of the ring that is visible, the ring of course crosses the planet to our sight at a point about midway between the planet's equator and its southern pole. I could see the black line caused by the shadow of the ring system falling on the bright ball of the planet very distinctly. To an observer who never had seen Saturn before in a telescope, the black line was at once apparent. Some lines also near the planet's equator were visible. The satellite, Titan, also was conspicuous, as were two other satellites, probably Dione and Rhea. No doubt Japetus was visible, but as it is so far out, and might have been any place within the entire field of the telescope, it was impossible, without having previously examined an ephemeris, to identify it. A most interesting circumstance, however, that I observed, was that Saturn is within less than 2° of the star cluster known as Praesepe, in the constellation Cancer. I could see both Saturn and Praesepe in the same quarter of the small one-inch finder of my telescope. A pair of opera glasses should easily disclose both planet and cluster in the same field of vision. I placed a friend at the eye-piece of the telescope, with Saturn centred in the field, and then, applying my eye to the finder, slowly moved the instrument until the central part of Praesepe had reached the centre of the eye-piece, then reversed the positions, and the observer was rewarded by the panoramic transformation, which caused great delight as well as surprise.

I viewed Mars in the telescope, and could see that it did not appear quite spherical. A rather noticeable "cutting away" at one side was apparent. I have seen in past years the polar snow cap of the planet, but although I saw some faint markings upon the central part of the planet, I could not say for certain that there

was any really distinct whitening of the planet towards either of its polar caps. I intend, however, to pursue that subject further. At present Mars is over twice as far from us as it was some years ago, and of course is apparently much smaller. This prevents much detail being visible.

A month ago Jupiter was almost exactly midway between Aldebaran and the Pleiades, and the proximity of these three conspicuous objects to one another was most attractive. This occurred three times, once when the planet was advancing, then when it was retrograding, and a third time, when the planet commenced to advance again. It will be the year 1930 before this occurs again.

TORONTO,
April 9, 1918.

OBSERVATORIES IN CANADA.

BY OTTO KLOTZ.

I HAVE had in view for some years writing a brief story of the earliest efforts to establish an observatory or observatories in Canada, but pressure of work has prevented me carrying out my object. A year or more ago I had occasion to ransack the Dominion or Public Archives in connection with astronomic observations along our eastern boundary line, that is, from the St. Lawrence to the St. Croix, and while so engaged embraced the opportunity to examine all available records referring to observatories.

The result of my researches are herewith transcribed. They are given chronologically and hence deal first with the Toronto observatory, and then with the one at Quebec.

The letters and numbers at the head of each refer to the volume as indexed in the Archives. In some instances the whole communication is stripped of its verbiage and the tenor thereof simply given.

Q. 388, p. 7.

Admiralty, 7 July, 1835.

C. WOOD, to WM. HAY, ESQ., Permanent Under-Secretary of State for the Colonies.

"A chain of observatories connects the western shores of Ireland and of Spain with the eastern coast of New South Wales, and thus comprises one-half of the globe, while the other half is in this respect entirely destitute of any such indispensible means of furthering the purposes of astronomy.

Nor do the more immediate practical objects of geography feel less the want of an observatory in that wide interval, as no standard meridian, nor any point to which comparative observa-

tions may be referred, exists throughout the whole continent of America. The establishment of a small observatory in Upper Canada would supply this important desideratum, which has been so strangely overlooked by the United States, and would thus reflect more honor in this country.

My Lords have been given to understand that the Observatory at St. Helena is about to be dismantled, and that the instruments which have been in use there would be available for the proposed observatory, thus reducing materially the expense to be incurred.

Should Lord Glenelg see no objection to this arrangement, my Lords would suggest that an inventory of these instruments should be furnished to this Department in order that it might be ascertained what further instruments it would be necessary to procure for the purpose."

I am Sir,

C. Wood,

Secretary to the Admiralty.

G. 74, p. 206.

Downing Street, 29 July, 1835.

Glenelg to Sir John Colborne, Lieut.-Gov. of Upper Canada.

In sympathy with the idea of establishing a small observatory in Upper Canada, and to utilize the instruments which have hitherto been in use in the Observatory of St. Helena.

(Baron Glenelg became Secretary for War and the Colonies in 1835.)

Q. 387, Pt. II., p. 328.

Toronto, 10 Nov., 1835.

R. H. Bonnycastle, Capt. Royal Engineers, to Sir John Colborne, Lieut.-Governor of Upper Canada.

Long letter about proposed observatory. Advantages of Toronto; discusses various sites there.

Q. 387, p. 328.

Toronto, U.C., 23 Nov., 1835.

Sir John Colborne to Rt. Hon. The Lord Glenelg.

"My Lord,—In reply to your Lordship's despatch of the 29th of July, No. 29, with which was transmitted a copy of a letter addressed to the Colonial Department, recommending 'a national observatory for the advancement of the purposes of astronomy to be established in Upper Canada', I have the honor to state that the want of this observatory on this continent being generally acknowledged, there can be no doubt entertained that the establishment of the Institution contemplated by the Lord Commissioners of the Admiralty will confer the greatest honor on our country. The clear atmosphere and equable temperature of the climate of Toronto appears peculiarly adapted for astronomical observations."

G. 76, p. 299.

Admiralty, 22 Feb., 1836.

C. Wood to Lord Glenelg.

Asks for estimate of cost of erection of observatory, and whether the Assembly would defray the expense and annual charge of maintenance, "with deference to the suggestion its being placed under the superintendence of the Professor of Astronomy of King's College."

Q. 86, p. 164.

Downing Street, 29th June, 1838.

Lord Glenelg to Sir George Arthur, Lieut.-Governor Upper Canada.

Reports instruments repaired and ready for shipment to the proposed observatory at Toronto, but recommends retaining them at Greenwich Observatory till he knows whether any steps have been taken towards the erection of the necessary buildings.

Q. 411, p. 25.

Admiralty, 21 May, 1838.

JOHN BARROW to SIR GEORGE GREY, Secretary of War and of the Colonies.

Mr. Airy, Astronomer Royal, reports seven cases of instruments from St. Helena, now repaired and ready for shipment.

"Pleased to acquaint Lord Glenelg that the instruments intended to be sent to the Observatory at Toronto are now ready, and that my Lords are desirous to know what steps have been taken on this subject in the Colony."

I am, etc.,

JNO. BARROW.

(Second Secretary to the Admiralty.)

(The above Sir George Grey, 1802-1894, appears later as Sir Henry George Grey, Viscount Howick.)

Toronto, 7 Jan., 1839.

LIEUT. J. C. B. RIDDELL, Royal Artillery, to Civil Secretary of the Province of U. C.

Reports on request.

Q. 413, p. 336.

Toronto, U. C., 9th Feb., 1839.

LIEUT.-GOVERNOR GEO. ARTHUR to RT. HON. THE LORD GLENELG.

Reports that nothing has been done towards the erection of an observatory to receive the instruments. In the present financial state of provincial finance, construction not probable.

G. 43, p. 323.

Downing Street, 20 Sept., 1839.

LORD JNO. RUSSELL to RT. HON. C. P. THOMSON.

Sir,—

"Her Majesty's Government having resolved to take meas-

ures for the erection of a Magnetic Observatory in Canada, I have to instruct you to appropriate a piece of ground in a suitable locality as the site of such observatory, and to afford to the officer who will proceed to Canada upon this service, every facility in the erection of the building and in the execution of the duties subsequently to be performed by him."

I have the honor, etc.

Note by O. K.—It will be observed that in the above is the first occurrence of the word "magnetic" observatory; hitherto the correspondence had been about an astronomical observatory.

Especially through the efforts of Sir Edward Sabine extensive magnetic observations were instituted in various parts of the British possessions and Toronto was one of the places selected. Lieut. C. J. B. Riddell, R.A., was the first incumbent of the office as Director at Toronto. He was invalided home in 1841, and Lieut. C. Younghusband, then serving in Canada, was placed in temporary charge of the observatory, to be succeeded by Lieut. J. H. Lefroy, who arrived in Canada from St. Helena in 1842.

Headquarters, Montreal, 28 Nov., 1840.

J. OLDFIELD, Lieut.-Col., Commander Royal Engineers in the Canadas, gives list of plans of Magnetic Observatory at Toronto:

1. Plan of position of grounds.
2. Plan of erection.
3. Plan of section and elevation, etc.
4.
5.
6.
7.
8.

Commenced April, 1840. Finished September, 1840.
Erected under the supervision Lieut.-Col. J. Oldfield.

QUEBEC.—On my request, Mr. W. Smith, of the Archives asked their Quebec Agent to search the Archives there, and Mr Roy replied as follows:—

Letter from P. G. ROY to WM. SMITH, of the Archives.

Quebec, March 8, 1917.

Translation from the French.

"In 1847 the harbor-master of Quebec, Captain Boxer, later admiral, The Chamber of Commerce of Quebec, the commander of the troops, Sir Richard Jackson, and Professor Airy, Astronomer Royal, saw the necessity of erecting an observatory at Quebec, for obtaining accurate time and furnishing the same to the merchant marine. In consequence the Imperial budget contained an appropriation of £526 16s. 6d. ($2,523.88) for the construction of this observatory. It was built during 1854 and 1855, and was within the citadel on Cape Diamond, between the pole of the "pavillon" and the former French works, in a S.W. direction. The building had a front of 26 ft. The main body of the building was 15 ft. high, 15 ft. deep, and 24 ft. long. The adjoining tower was 44 ft. high. The first astronomer named by the British Admiralty was Lieut. Ashe of the royal marine. He entered on his duties in 1850. Later in 18—, the observatory was installed on the Plains of Abraham, near the present prison, in a house called 'The Bonner property." This building was nearly 60 ft. long and 30 ft. in depth. An adjoining tower was built. The first instruments of the Quebec Observatory were furnished by the Observatory at Greenwich and were a meridian circle with a telescope of 42 inches and a sextant. Two clocks were also bought. In 1864 an equatorial of 8-inch aperture was bought from Alvan Clark, Boston, for $2,500. This equatorial was put in place in May, 1864, in the tower of the Bonner property."

State Book P, p. 404.

Quebec Observatory, Aug. 11, 1855.

"On an application from Lieut. E. D. Ashe, R.N., in charge of the Quebec Observatory, for authority to incur the expense of

taking a wire to the Observatory in connection with the line of the British-American Telegraph Company, and further to procure an apparatus at an expense not exceeding £30, to enable him to determine the longitude of the observatory by telegraphic signals to and from Frederickton, and the longitude of the most important places in Canada by the same means."

"The Committee recommends that the authority requested be granted."

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p. 17.

In the following Analytical Index is a resumé of some essential documents with reference to the two observatories.

"Analytical Index to the State Books, Vol. VII., 1841-1867. Privy Council."

K In this volume, pp. 21-27, under the entry "Observatories," are many entries, mostly under the heading Quebec and Toronto. The first, under Quebec, is of date April 23, 1850, £500, the estimated cost of the erection of the building, to be placed to the credit of the Ordnance Store.

M March 12, 1852. Lieut. E. D. Ashe, R.N., in charge of the Observatory.

P Aug. 11, 1855. Longitude of the Observatory from Frederickton by wire. (See separate sheet for copy.)

R Dec. 22, 1856. Lieut. Ashe suggests establishment of a proper Astron. Observatory and submits plans. Not adopted.

TORONTO.

N Feb. 3, 1853. Capt. Lefroy reports that the Military establishment is to be withdrawn.

N May 23, 1853. Observatory and ground attached to it placed under the management of the Professor of Natural Philosophy.

N May 23, 1853. Temporary management by Professor J. B. Cherriman at £150.

P May 22, 1855. Professor Cherriman appointed Superintendent of the Observatory and Professor of Meteorology, and observatory placed under the supervision and control of the Senate.

P Aug. 11, 1855. Professor Cherriman declines the appointment, and G. T. Kingston appointed.

It is hoped that in the near future the writer will describe the birth of the Dominion Observatory, the immediate reason for its creation, and who were the persons to whom its erection is due.

DOMINION OBSERVATORY,
OTTAWA
January 5, 1918.

DISTANCES OF TWO STAR CLUSTERS

By W. H. Pickering

(*Harvard Circular*, No. 206)

I. The Pleiades

THE method of determining the stellar parallax suggested by Russell, in *Popular Astronomy*, 1914, **22**, 291, is particularly well adapted to measuring the distance of clusters. He gives a formula for determining the absolute magnitude of a star, dependent on the type of its spectrum. This formula expressed slightly differently reads $M = 0{\cdot}6 + 2{\cdot}1\ (t - 2)$, where M is the absolute magnitude, and t is the type, counting B as 1, A as 2. F as 3, G as 4, and K as 5. He states that the residuals from this formula for the mean magnitudes of the observed stars of the different classes average $\pm 0{\cdot}29$. This corresponds to a mean error in the distance of the star of 0·14, or only one-seventh.

In the H. R. are given the brightness and types of the thirteen brighter stars in the Pleiades. Two of them however have peculiar spectra, one of them giving bright lines. They are therefore ruled out, leaving eleven, of which six belong to type $B5$, and five to type $B8$. In *Popular Astronomy*, 1918, **26**, 9, is given a paper by Trümpler on the constitution of the Pleiades. He uses the Potsdam magnitudes, but they agree so closely with the Harvard values that the formula can be applied without error. He states that the group contains fifteen stars between magnitudes 6·5 and 7.5 whose mean type of spectrum is $A0$, twenty-seven stars between 7·5 and 8·5 whose mean type is $A1$, and twenty-nine stars between 8·5 and 9·5 whose mean type is $A9$.

These results are entered in Table I, where the first column gives the type, the second the number of stars considered, the third their mean apparent magnitude, the fourth their absolute magnitude computed by the formula, and the fifth the difference

between the two. The results in this column should all be identical if the facts are as stated, and the formula accurately represents the facts. We found in our paper on the Distance of the Orion Nebula, *Circular* 205, that scattered among the giant stars of type *B* were a few supergiants. We may assume that the same holds true in the case of the Pleiades, although their brilliancy is by no means as marked as in the case of Orion. Five of the six brightest stars in the cluster belong to type *B*5. Omitting therefore this type, and taking the mean of the other numbers, we find 6·46 as the mean difference of the magnitudes. The sixth column gives the deviations from this value, and shows an average deviation of ± 0·39, a result slightly larger than that

TABLE I.

THE PLEIADES

Type	No.	App.	Abs.	Diff.	Dev.	Parsecs	Years	Ratios
B5	6	4·14	−0·45	(4·59)		(83)	(270)	
B8	5	5·91	+0·18	5·73	−0·73	140	456	0·70
A0	15	7·00	+0·60	6·40	−0·06	191	621	0·95
A1	27	8·00	+0·81	7·19	+0·73	274	893	1·36
A9	29	9·00	+2·49	6·51	+0·05	200	653	1·00
Mean				6·46	±0·39	201	656	±0·18

given by Russell as derived from all the observed stars. The difference of magnitude multiplied by 0·2 gives us the logarithm of the distance of the group stated in units of 10 parsecs, or dekaparsecs, dps, if we may suggest the name. The various distances in parsecs and in light years are indicated in the seventh and eighth columns, their mean values, omitting the first type, being 201 and 656, respectively. The last column gives the ratios to the mean distance, derived from the four different types of stars, the average deviation being ± 0·18. The reciprocal of 201 gives us the mean parallax of the group 0″·0050 ± 0″·0008. The Pleiades are consequently just five times as remote as the Hyades, and as seen from the Hyades would appear much as they do to us.

The apparent distance between the two farthest apart of the

six bright stars is 63′. The real distance between them is therefore at least 12·0 light years. The diameter of the whole group according to Trümpler is about 6°, or seventy light years. The apparent magnitude of Alcyone, the central star of the group, is 2·96, and subtracting the correction for distance 6·46 gives us an absolute magnitude of − 3·50, which is 8·3 magnitudes, or 2100 times brighter than our sun. The other five bright stars average 800 times as bright, and their real distances from Alcyone, assuming the latter to be centrally located, are about the same as that from the sun to Sirius. Since they are in reality 16 times brighter than the latter body, they would appear as seen from Alcyone of about the same brightness as Venus at its brightest does to us. The three close companions of Alcyone, however, although really much fainter, would on account of their proximity appear about equally bright.

II. Coma Berenices

This cluster, although not conspicuous like the Pleiades, is interesting as being one of those in our immediate neighborhood. A negative of this region of the heavens was first taken with a wide angle lens of thirteen inches focus. On examination it was found that the brighter stars of the group fall off in numbers very rapidly after passing magnitude 6·5, and that the density of the fainter stars appears no greater within than without the group. The cluster lies between R.A. $12^h\ 10^m$ and $12^h\ 30^m$, and between Dec. + 23° and + 28°, an area of about 5° on a side. Within this area twenty stars are included in the H. R., ranging in brightness from 4·78 to 6·69. Two of them are ruled out as having peculiar spectra, and three more because their proper motions are very different from those of the rest of the group. Counts in equal areas of the sky preceding and following the cluster show that two to three stars of this brightness may properly be allowed as occurring on the background in this portion of the heavens.

The remaining fifteen are entered in Table II. which is arranged precisely like Table I. Twelve of these stars belong to

TABLE II.

COMA BERENICES

Type	No.	App.	Abs.	Diff.	Dev.	Parsecs.	Years	Ratios
A0	4	6·17	0·60	5·57	+0·81	130	424	1·41
A2	3	5·43	1·02	4·41	−0·35	70	248	0·82
A3	3	6·19	1·23	4·96	+0·20	98	320	1·06
A5	2	5·73	1·05	4·68	−0·68	65	213	0·71
F0	1	6·30	2·70	(3·60)				
F5	1	5·49	3·75	(1·74)				
G5	1	5·00	5·85	(−0·79)				
Mean				4·70	±0·51	92	301	±0·24

type *A*, and all of them are probably included in the cluster. The remaining three belonging to types *F* and *G* may be nearer objects superposed upon it, or they may be giant stars within it, like Aldebaran in the Taurus cluster and Antares in the moving cluster in Scorpius. In any case the formula would not apply to them, since it is adapted only to dwarf stars. It seems likely that these three yellow stars really belong to the cluster, but the suggestion is made that since the last one, H.R. 4667, is brighter than it should be even if as near as 10 parsecs or 33 light years, and as it has a considerable number of possibly more remote but equally bright companions, it would be a good subject for a parallax campaign.

The distance of the cluster appears by the table to be only 301 light years, and therefore to be one of our very nearest neighbors among the clusters, thereby corroborating our natural conclusions based on the brightness and scattered character of its component stars. Its parallax is $0''\cdot0109 \pm 0''\cdot0026$, which is perhaps not a very large uncertainty, considering the small number of stars and the large number of groups into which they are divided. The group is 4° or some twenty-five light years in diameter. The average apparent brightness of its twelve components of type *A* is 5·91, and their mean absolute magnitude is therefore 1·15. Their average brightness is consequently 3·65 magnitudes, or 29 times greater than that of our sun.

March 5, 1918.

MEETINGS OF THE SOCIETY

At Toronto

March 12,—The regular Meeting of the Society was held in the Rooms, 198 College St., at 8 p.m. The President, Mr. A. F. Miller, in the chair.

Mr. Harry G. Nicholls, 422 Sherbourne St., Toronto, was elected a member.

Mr. W. E. W. Jackson reported that the Aurora of March 7th had affected the magnetic instruments as shown by the records at the Observatory. Mr. J. P. Henderson also mentioned that the same Aurora had affected wireless communication and records.

Prof. C. A. Chant gave the address of the evening on the "Total Solar Eclipse of June 8th next." The lecturer first discussed the causes of eclipses in general, and illustrated the subject by means of lantern diagrams. The number of eclipses we may have in a year depends on the arrival of the moon at a node in its orbit. This takes place at intervals of 173 days. Accordingly, we are sure to have two eclipses of the sun every year, and there may be even as many as five eclipses of the sun in the year. It is not necessary to have any eclipses of the moon in the year, and three is the largest annual number of moon eclipses that can take place. In 1917 there were seven eclipses, the largest number that can occur in any year. One object in photographing total solar eclipses is to study the sun, especially the corona, which becomes visible only during a total eclipse. Prof. Chant showed the path of the coming solar eclipse by the use of maps projected by lantern, some of which showed the percentage of the face of the sun eclipsed along belts on each side of the zone of totality.

In reply to questions, he said that in connection with the total solar eclipse of 1905, which the expedition with which he was associated failed to see on account of bad weather, it was intended that he should use the polariscope to examine if the corona consists of polarized light, and it is probable that this will be the work he will undertake during the coming eclipse. There is not as yet any definite international subdivision of the work that will be undertaken during the eclipse.

March 26.—The regular meeting was held in the Society's Rooms, 198 College St., at 8 p.m., the President, Mr. A. F. Miller, in the chair.

A communication was received from Mr. Forsyth regarding the organization of a divisional Centre at Calgary.

Seven new Members were elected as follows:—

Norman H. Taylor, 169 Westminster Ave., Toronto.
Rev. Frederick Daniel Meader, B.A., St. Michael's College, Toronto.
Rev. George Taylor Munro, Gore Bay, Ont.
Edward Jones, 32 Applegrove Ave., Toronto.
David O. Jones, 32 Applegrove Ave., Toronto.
Charles A. Wright, 3002 Glencoe Rd., Calgary, Alta.
A. H. Crease, 638 Manning Ave., Toronto.

Mr. A. F. Miller showed two sketches of Mars that he had made on March 20 and 22, and called attention to persistent patches near the preceding limb at some distance from the polar caps of the planet. He also reported having recently seen a spot on one of the belts of Saturn.

Mr. R. M Motherwell, M.A., of the Dominion Observatory, Ottawa, gave the paper for the evening on "Variable Stars." When he began the study of variable stars, he had wished that Ptolemy had used some other word than magnitude for his six classes of stars, as the term is applicable only to a star's brightness, not to its size.

Sir Wm. Herschel added exact ratios to the six magnitudes,

and Argelander next gave the first good star catalogue that astronomers could use.

The first real variable to be identified as such, near the end of the sixteenth century, was Mira, with a period of about eleven months. Later, in the seventeenth century, came the identification of Algol as a variable, with a short period of about three days. Since then a very large number of other variables have been added to the known list, and the wonder is that all stars are not yet found to be variable, as they may be when more accurate instruments are brought into use in the future. He would hesitate to say whether any star in the sky gives a perfectly constant light.

In the lantern illustrations he showed the elaborate small building or "camera hut" which is used for this work at Ottawa, and also showed and explained the instruments used for making the photometric measurements. The method of working in use at Ottawa, is to photograph star images out of focus so as to give a disk on the photographic plate, and then refer the image to be measured for comparison with Polaris as the standard. In addition to this, they use a large objective prism to photograph a field of stars, as they must know the spectral type of a star when measuring it photometrically.

The lecturer offered an attempt at explanation of certain light curves of variables, on the assumption that at regular intervals we look at the source of light through thicker media of gaseous envelopes than at other times. Using Algol as a type of eclipsing binaries, he showed a light curve of its period, adopting the theory of eclipsing pairs to explain this type. He did not insist, however, on the adoption of any theory, as there are theories and theories, and if we start in this line we cannot end.

They find that many of the so-called spectroscopic binaries are not binaries at all. Between 800 and 1,000 variables have been catalogued by astronomers and are closely studied.

A. F. HUNTER,
Recorder.

REVIEW OF PUBLICATIONS

Lessons in Astronomy, including uranography, by CHARLES A. YOUNG. 420 pages, 4 maps. Boston and New York: Ginn & Co., 1918. Price $1.25.

This is the most elementary of the well-known series of four text-books on Astronomy prepared by the late Charles A. Young. It was originally published in 1891, and after a thorough revision was reprinted from new plates in 1903. The present issue was prepared for the press by Dr. Anne Sewell Young, professor of Astronomy in Mt. Holyoke College, a niece of the author of the text. By her the work has been brought up to our present knowledge of the subject.

Young's books are so widely known and so highly valued that it is hardly necessary to describe this volume at any length. But, for the benefit of any one unacquainted with it, it may be stated, that in this book the treatment of the subject is adapted to those of slight mathematical attainments; that in chapter 2, which runs to 43 pages, there is a good description of the constellations, accompanied by four good maps; that the illustrations and printing are of high class; and that more detailed information about some of the more difficult matters is given in the appendix, which also contains several numerical tables.

The Mystery of Matter and Energy. Recent progress as to the structure of matter, by ALBERT C. CREHORE, Ph.D. 172 pages, with illustrations. New York: Van Nostrand, 1917. Price $1.00

This little book aims to give a concise account of the striking

investigations made during the last few years into the nature of matter. It is written in a scholarly and readable style and will be found to interest both the general reader and the scientific worker. The earlier chapters deal with the atomic constitution of matter, the electron and its charge, electromagnetic waves, the motion of the ether with respect to matter, the relativity hypothesis, and X-rays with their applications to crystals. The latter portion of the book is more hypothetical and discusses in considerable detail some of the author's own investigations. Much of it treats of the arrangements of atoms in crystals, a subject very difficult to explain without models. Several folding plates are given, showing the lines of force about variously constituted atoms. These are very beautiful but very intricate. They recall the geometrical machine-drawn decorations on bank-notes. The book should arouse still greater interest in the attempts which are being made to solve the great fundamental problem of physical science, namely, the structure of matter and its connection with energy.

C. A. CHANT.

NOTES FROM THE METEOROLOGICAL SERVICE

Summary Report of the Weather in Canada

March, 1918

Temperature.—The temperature was above the average from the eastern half of British Columbia to the Quebec boundary, and below elsewhere in the Dominion. The negative departure was 3° on the coast line of British Columbia, from 3° to 6° over the greater part of Quebec, and 6° in the Maritime Provinces. The positive departure ranged from 3° in the extreme western portion of Alberta, to 15° in Southern Manitoba, while in Ontario it was from 3° to 6°.

Precipitation.—The precipitation was below the average in all portions of the Dominion, except at a few points in Alberta and Saskatchewan, and along the coast line of British Columbia, where there was an excess. The deficiency was very marked from Ontario to the Maritime Provinces. In Ontario many points recorded from one to three inches less than the usual quantity, Quebec from one and a half to three inches less, and the Maritime Provinces from one to two and a half inches less.

At the close of the month snow still lay on the ground to a depth of from 10 to over 30 inches in the Province of Quebec and in Northern New Brunswick. There was also a considerable snow covering in the far northern portions of Ontario and British Columbia, elsewhere there was none left except patches where heavy drifting had occurred.

Temperature for March, 1918

Station	March		Station	March	
	Highest	Lowest		Highest	Lowest
Yukon			Kenora	56	-14
Dawson	26	-40	Kinmount	57	-16
British Columbia			Kingston	54	- 4
Atlin	36	-34	Kitchener	68	4
Agassiz	60	20	London	73	4
Barkerville	47	- 5	Lucknow	64	- 4
Kamloops	70	8	Markdale	63	- 1
New Westminster	64	19	North Gower	55	-12
Prince Rupert	50	11	Oshawa	54	14
Vancouver	58	21	Ottawa	55	- 4
Victoria	60	28	Paris	70	5
Western Provinces			Parry Sound	59	- 4
Battleford	62	-23	Peterboro'	64	- 4
Calgary	66	-20	Port Arthur	60	- 9
Edmonton	62	-28	Port Burwell	64	3
Medicine Hat	68	- 6	Port Dover	63	5
Minnedosa	62	-24	Port Stanley	56	5
Moose Jaw	71	-10	Queensborough	56	-11
Oakbank	62	-21	Ronville	56	2
Portage la Prairie	61	- 7	Southampton	60	5
Prince Albert	60	-20	Sundridge		
Qu'Appelle	64	-16	Stonecliffe	58	-14
Regina	65	-17	Stony Creek	70	6
Saskatoon	62	-22	Toronto	67	6
Souris	65	- 6	Uxbridge	57	- 2
Swift Current	68	-14	Wallaceburg	69	10
Winnipeg	64	-14	Welland	66	13
Ontario			White River	55	-34
Agincourt	65	1	*Quebec*		
Aurora	68	- 5	Brome	58	-22
Bancroft	59	-15	Father Point	42	-14
Barrie	64	- 2	Montreal	52	2
Beatrice	56	- 8	Quebec	46	- 8
Bloomfield	50	9	Sherbrooke	54	-14
Brantford	67	6	*Maritime Provinces*		
Chapleau	61	-33	Charlottetown	44	-16
Chatham			Chatham	50	-22
Clinton	63	- 4	Dalhousie		
Collingwood			Fredericton	54	-27
Cottam	69	13	Halifax	54	- 6
Georgetown	66	2	Moncton	52	-24
Goderich			St. John	55	- 8
Gravenhurst	60	- 4	Sussex	50	-22
Grimsby			Sydney	48	- 6
Guelph			Yarmouth	48	0
Haliburton	58	-16			
Huntsville	65	-12			

MAGNETIC OBSERVATIONS

FEBRUARY, 1918

At both Agincourt and Meanook Observatories during the month of February the Magnetic Forces were comparatively quiet. Small disturbances were recorded on the 5th, 11th, 12th, 13th, 23rd and 28th and in each case they were active during the night and early morning hours only.

Auroræ were reported by Meteorological observers generally on the 5th, 11th and 12th and locally on the 28th.

Very little sunspot activity was observable during the month, although small spots could always be seen on the sun's surface.

AGINCOURT MAGNETIC OBSERVATIONS

Lat. 43° 47′ N.; Long. 79° 16′ W.

February, 1918		D. West	H	Z	I
		° ′	γ	γ	° ′
	Mean of Month	6 37·7	15931	58416	74 46·7
	Maximum	7 13·1	15988	58567	
	Date of Maximum	11	5	12	
	Minimum	6 01·8	15800	58340	
	Date of Minimum	10	13	11	
	Monthly Range	1 11·3	188	227	
Mean Daily Amplitude	From hourly readings	9·0	33	18	
	From means of extremes	20·9	70	36	

MEANOOK MAGNETIC OBSERVATIONS

Lat. 54° 37′ N.; Long. 113° 21′ W.

February, 1918		D. East	H	Z	I
		° ′	γ	γ	° ′
	Mean of Month	27 46·5	12933	60399	77 54·8
	Maximum	28 44·4			
	Date of Maximum	12			
	Minimum	26 43·2			
	Date of Minimum	12			
	Monthly Range	2 01·2			
Mean Daily Amplitude	From hourly readings	7·9			
	From means of extremes	35·0			

H and Z are given in Gammas. (1 γ = 0·00001 C.G.S.).

All results are reduced to International Magnetic Standard.

The value for I at Meanook is the mean of all the observations made during the month without regard to the time of day.

The value of H at Meanook is the mean of two observations made about the middle of the month, and the Z is obtained by the formula Z = H tan I.

W. E. W. J.

Earthquake Records by the Milne Seismograph

TORONTO

Sir Frederic Stupart, Director.

P.T. = Preliminary Tremors. S. = Secondary Waves. L.W. = Large Waves. A.C. = Air Currents. Time is Greenwich Civil Mean Time, 0 or 24 h = midnight.

No.	Date 1918	P. T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
		h m	h m	h m	h m	h m	mm	
1827	Mar. 11			16 38·0) 16 48·6)		16 59·3	0·2	Micros. going on.
1828	" 16			13 53·1?) 13 55·8)	13 56·7	14 30·6	0·3	
1829	" 19			6 57·8	7 02·9	7 32·4	0·8	Marked gradual thickening.
1830	" 19			7 59·7) 8 5·9)			0·05	
1831	" 20			1 48·2		1 52·2	0·05	
1832	" 20			2 06·4		2 11·9	0·05	[mic.
1833	" 21			1 11·1	1 12·3	1 16·3	0·2	May not be seis-
1834	" 21			4 01·6?) 4 10·2?)		4 21·4?	0·1	May not be seis- [mic.
1835	" 21			16 55·8		17 03·1	0·05	
1836	" 21			17 18·6) 17 20·6)	17 26·7	17 35·8	0·2	Grad. thickening
1837	" 22			6 32·6	6 32·8	6 41·2	0·2	

Marked micros. on the night of the 21st and morning of the 22nd.
Quake on 26th lost, attending instrument.
Boom period 18 seconds. Pillar inclination 1mm. = 0″·45.

VICTORIA, B. C.

F. N. Denison, Superintendent.

No.	Date 1918	P.T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
		h m s	h m s	h m s	h m s	h m s	mm	
1832	Mar. 16				14 00 00		0·2	
1833	" 19			6 38 51) 6 39 24)	6 46 43	7 19 40	1 0	Marked gradual thickening.
1834	" 20			1 56 35	2 00 28	2 11 21	0·4	
1835	" 20	19 51 41		19 54 09	19 55 37	20 01 32	0·7	1410 km.?

No trace from 20h 01m of 20th to 19h 53m of 21st.
On 22nd centre line so thick, impossible to detect a small quake.
Boom period 18 seconds. Pillar inclination 1mm. = 0″·54

Vertical Seismograph

Date 1918	P.T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
	h m s	h m s	h m s	h m s	h m s	μ*	
Mar. 19				6 41 30		2	*True earth movement.

J. Y.

ASTRONOMICAL NOTES

AURORA BOREALIS.—At last week's Royal Geographical Society's meeting the Aurora Borealis was under discussion. Dr. Chree opened with a well illustrated account of the work, mostly recent, done principally by Scandinavian investigators. The region of greatest auroral frequency, he said, is a curve in high latitude, not centred about the geographical nor about the magnetic pole, but enclosing both and passing along the northern coast of Norway, where most of the work was done. In those regions most are seen at mid-winter, while further south the maximum is at the equinoxes. The hour of greatest frequency in the North is about 10 p.m., but the corresponding feature of the Antarctic is found by Sir Douglas Mawson to have its maximum at 3 a.m. The sharp lower edge of the auroral "curtain" does not confirm the theory that it represents the lowest point of the atmosphere to which certain solar radiations can penetrate, as in that case there should be a maximum of brightness higher up. It is now suggested that the phenomenon is due to Alpha rays. In 1874, Cavendish deduced the height of the "lights" to be between fifty and seventy miles. Modern determinations from many hundreds of observations show heights ranging from quite low altitudes up to something like 250 miles, with marked maxima at sixty-two miles and sixty-six miles. The maximum comes further south at sunspot maximum, so that it appears that the sun's radiation has greater penetrating power at sun-spot maximum. The sun's rotation period is also shown, last week's aurora being an echo after three complete rotations of the striking aurora of December 16 last. Professor Fowler, Professor Strutt, and the Chairman, Sir Napier Shaw, took part in the discussion.—*English Mechanic and World of Science*, No. 2765.

PLANETARY PERTURBATIONS AND ÆTHER-DRIFT.— In a paper entitled "Continued Discussion of the Astronomical and Gravitational Bearings of the Electrical Theory of Matter" (*Philosophical Magazine*, February, 1918), Sir Oliver Lodge continues a discussion commenced by the suggestion that the shift in Mercury's perihelion might be explained by a drift of the solar system through the æther. Professor Eddington showed that a drift that would account for this would bring inadmissibly large errors into the other elements of the inner planets. Sir Oliver Lodge admits an error in his former work in the following words: "If the additional inertia due to motion is acted on by gravity the varying factor m will enter twice into the equation of motion and the perturbation will be increased instead of being annihilated." Making this change, he examines once more whether it is possible to find a drift that will satisfy the observed perturbations within their limits of error. After many trials, he concludes that they cannot all be satisfied in this way. He tends to the conclusion that gravity has joined the conspiracy to defeat our efforts to detect motion through the æther, and that we are led to accept the conclusion that the gravitation-constant itself is a function of the speed of the attracting masses. In support of this he quotes some electrical results which lead him to believe that electrical attraction does actually vary with speed. "If such a fact be established [for gravity] it may begin to throw some light on the family relationship of that force.—*Nature*, March 28, 1918.

HYPOTHESIS TO ACCOUNT FOR THE SPECTRAL CONDITIONS OF THE STARS.—The peculiar behavior of double stars in the near and relatively distant regions of the galaxy, which has just been discovered, together with the well-known preference of the stars of type *B* for the Milky Way and the general preference of the later types for the nearer regions of space, suggest the conclusion that spectral class depends largely upon external causes.

Further study of the brightnesses and spectra shows that there is a strong similarity between the brighter stars of early type if arranged in the order *B*, *O*, gaseous nebulæ, and the

changes in the novæ in their early stages. As is well known, all of these objects are confined to relatively distant regions in the direction of the galaxy. There is also reason to think that the same cause which is believed to underlie the phenomena of the outbursts in the novæ may be a vital factor in the determination of spectral class among the ordinary stars.

As a result of these investigations the following general hypothesis has been formulated to account for the present classes of stellar spectra.

Hypothesis.—The cause is dual, depending upon the amount of cosmic matter and upon phenomena of radiation and condensation. Many of the *A* stars, the *B* and *O* stars, the planetary and irregular gaseous nebulæ, the novæ and perhaps the Cepheid variables, are confined to the galaxy because there the matter is sufficiently plentiful to cause an increase of energy, the energy from the matter swept up being in excess of that lost by radiation. The direction of spectral change under such conditions in *toward the nebulæ*.

In the regions (distant or near) where there is little or no cosmical matter, radiation will be in excess of the energy received from external sources and the direction of change will be *toward the late types*.

In a considerable portion of the system the changes of spectral class may be due simply to retardation.

The hypothesis may be further generalized as follows—

The spectral condition of a star depends chiefly upon its size and mass and the external conditions of density of cosmical matter and relative velocities of star and matter.

Upon this hypothesis the stars are probably all pursuing one definite course of very slow change toward extinction, but each individual star will be pursuing a course which may have many whole or partial cycles due to varying external causes.—C. D. Perrine, *Proceedings National Academy of Sciences, U.S.A.*, March, 1918.

Why the Atmosphere Generally is Unsaturated.—It may, perhaps, seem strange that, in spite of the continuous and

rapid evaporation from nearly all parts of the earth's surface, the atmosphere as a whole never becomes even approximately saturated. This condition, however, is a necessary result of vertical convection. Obviously whatever the temperature and relative humidity of a given mass of air at any point of its convectional route, its absolute humidity is less then, in general, than when its ascent began, by the amount of rain or snow already abandoned by it. That is, on the average, air in a convection circuit descends to the earth dryer than when it previously ascended from it. In short, convection, because it induces abundant precipitation is therefore a most efficient drying process; and because comparatively little precipitation is produced in any other way, convection alone prevents the atmosphere from becoming and remaining intolerably humid.— W. J. HUMPHREYS, in *Journal Franklin Institute*, April, 1918.

THE NEBULA N. G. C. 1068 (*M77*).—This little nebula, about one degree southeast of the star δ Ceti, has perhaps the highest velocity of all the heavenly bodies now known. Two other spiral nebulæ, N.G.C. 4565 and 4594, have nearly as great velocities. They are in roughly the opposite part of the heavens and receding, as is N.G.C. 1068.

It is difficult to conceive how such enormous velocities (over 1000 kilometers per second) can have been generated, limiting one's self to purely physical considerations and the assumption of the universality of the law of gravitation. There does not appear to be evidence of the existence of enough matter in the whole sidereal universe, so far as our telescopic vision has penetrated, to have produced such acceleration, even though the nebulæ should have fallen from infinity and should now be very near the centre of the universe. These nebulæ, however, appear to be many thousands of light-years apart and cannot all be close to the centre.

Besides indicating the high velocity of the nebula as a whole, the lines are inclined through an angle of about five degrees, indicating a rotation of the nebula about its shortest axis, the speed

of rotation amounting to about 300 km. per second at a distance of 1′ from the nucleus. This rotational speed is higher than that of any other object yet observed, that of the nebula in Virgo, N.G.C. 4594 being the next highest. If we read Mr. Slipher's interpretation of the spectrograms and direct photographs of the nebula correctly the rotation is inward, ... "the inner part of the nebula (all that is recorded on the spectrograms) is turning into the arms of the spiral like a winding spring."

A letter received from Director Slipher after this note was in type confirms the above statement, Mr. Slipher also states that the − sign was given inadvertently to the velocity in *Bulletin* No. 80. It should be + as given in this note.—*Popular Astronomy*, April, 1918.

The Mandeville Station.—The Mandeville Station in Jamaica has continued under the direction of Professor W. H. Pickering. Some of the more important investigations conducted are the following:—The color of the sun, stars, and planets by means of a color scale. A selection of the sixty finest objects in the sky. A study of the transparency of our atmosphere, showing that the most southern star readily visible to the naked eye from Mandeville is γ Volantis, magnitude 3·7, declination − 70°·3, maximum altitude 1°·7. A study of the shifting white areas on the summit of the central peaks, and on the inner rim of the lunar crater Theophilus. These were attributed severally to snow and clouds. A compilation and study of the results secured at the past opposition by the various members of the "Associated Observers of Mars." Report No. 17 on Mars. An investigation of the Orion nebula, indicating that its distance is a little over 6,000 light-years. The measurement of the changing forms of Jupiter's satellites.—*Annual Report*, Harvard College Observatory, for the year 1917.

J. R. C.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries.

REFORMS IN TIME-KEEPING.

The "daylight-saving" plan came into force in the United States on March 31 and in Canada on April 14. Some opposition to the measure was shown by representatives from the country districts, where the benefits to be derived from it are not so marked as in the cities, but an earnest trial for the summer season will probably show that for a large majority of the people the scheme is of great value.

The present writer had collected information on several other matters relating to time-keeping and was about to prepare a note for this column when he received *The Scientific American* for April 13, and found in it the following excellent summary:—

We are living in an age of revolutions; the strongholds of conservatism have been broken down, and in all spheres of human activity novelties are the order of the day. In the matter of time-keeping several interesting innovations are now either on trial or under consideration.

1. The so-called daylight-saving plan, which was an object of ridicule a few years ago, is now in operation over the greater part of the civilized world.

2. The standard time zones of the United States have at last, by the terms of the daylight-saving law, been given federal recognition, and the Interstate Commerce Commission has been instructed to delimit them. These zones were originally adopted by the railways, and have been legalized by some of the state legislatures, but not previously by the Federal Government.

3. A movement on foot in New Zealand to bring the standard time of that colony into conformity with the system founded on the meridian of Greenwich will probably be taken up in the other colonies and countries where, as in New Zealand, standard time now differs by half-hours from the regular hour zones. New Zealand time is now 11½ hours faster than Greenwich time, and the proposal is to make it 12 hours faster. Similar reforms are needed in India, Burma, South Australia, Nigeria, British East Africa, Venezuela, Hawaii, Samoa and Guam.

4. The use of standard time at sea is on the point of supplanting the present heterogeneous system of shipboard time. This reform has already been put in operation in the French and Italian Navies.

5. A proposal to change the beginning of the astronomical day from noon to midnight, in order to conform to the civil day, is being discussed by the astronomical societies and authorities of Great Britain and America.

6. A similar change in the nautical day was recommended by the British conferees above mentioned.

7. The plan of numbering the hours of the civil day from 0 to 23, thus abolishing A. M. and P. M., continues to make progress. The latest country to adhere to this plan for official purposes is Greece, while a strong movement in favor of it is reported from Switzerland.

All of these reforms except the first are steps in the direction of consistency and uniformity, and are logical results of improved methods of communication between and within nations. Parochial systems of time-keeping no longer serve the needs of humanity. Even the mariner in midocean no longer has any excuse for keeping time by the sun, now that wireless has brought him into constant connection with *terra firma*.

The future may witness even more sweeping reforms. For many practical purposes it would be an advantage to use the mean solar time of Greenwich throughout the world. At present, when we read in the newspapers that some distant event has occurred or

will occur at a certain time, we must perform a mental calculation to determine the hour and often also the date of its occurrence according to our own clocks and calendars—truly a paradoxical situation in an age when the telegraph is supposed to have annihilated space.

UNIFICATION OF CIVIL AND ASTRONOMICAL TIME.

A circular has been issued by the Royal Astronomical Society, dated March 8, and signed by Messrs. A. Fowler and A. C. D. Crommelin, honorary secretaries, regarding the proposal to substitute the civil for the astronomical day; and as the matter is of great importance and is treated in a very clear and concise manner, the circular is printed herewith. Canadian astronomers might communicate their views directly to above-mentioned secretaries, or they may express them in this JOURNAL and copies will be sent to London. The circular is as follows:—

A letter has been received by the Council of the Royal Astronomical Society from the British Admiralty, forwarding a Report of a Conference on Time-keeping at Sea, and asking them

"To ascertain the views of Astronomers generally on the proposal which was made by the Conference that the day should be shown in nautical publications as commencing at midnight instead of at noon, and the Civil Day substituted generally for the Astronomical Day.

"Their Lordships would be glad to be advised whether it would be practicable to introduce this change in the *Nautical Almanac*, without excessive confusion, as to the best means of reducing such confusion, and as to what other documents will require to be similarly treated."

The question has been raised in an informal manner in the *Observatory* Magazine, and the general trend of the replies favored a change, and pointed out that—

(1) If a change is made, it should be made simultaneously in the different Almanacs;

(2) That the year 1925 is the earliest date at which such a change could be conveniently introduced;

(3) That there should be no alteration in the system of reckoning by Julian days, which should begin, as heretofore, at Greenwich noon.

With these expressions of opinion in mind, a Committee appointed by the Council of the Royal Astronomical Society proceeded to consider in detail the changes that would be required in the *Nautical Almanac*.

The Committee, of which the Superintendent of the *Nautical Almanac* is a member, reports as follows:—

> Taking the *Nautical Almanac* for 1920 as a standard, the following are the alterations that would be necessary if the day were made to begin at midnight. They are classified in three groups.
>
> Group A. Meridian Passage Type.
>
> *Examples*:—
>
> Transit of First Point of Aries (page iii).
> Moon's Meridian Passage.
> Meridian Passage of all Planets.
> Upper Culmination of the 23 circumpolar stars.
> Transit of Zero Meridian for physical ephemeris of Mars.
>
> In this group all times have to be altered by 12 hours: if the day is thereby changed, the entry is displaced by one line. Days of double transit, or of no transit, occur at different places.
>
> Group B. Marginal Dates Type.
>
> *Examples*:—
>
> Moon's Hourly R.A. and Decl.
> Places of all planets at transit at Greenwich.
> Solar date of star transits at Greenwich (pp. 277-392).
> Moon at transit.
>
> In this group the main entry (*e.g.* R.A. of Moon at transit) is unaltered, but the date under which it is entered is altered by 12 hours.
>
> Group C. Solar Time of Various Phenomena.
>
> *Examples*:—
>
> Phases of Moon.
> Beginning of Bessel's Year.
> Phases of Eclipses.
> Occultations. Time of Conjunction in R.A.
> Occultations. Time of Dis. and Re. at Greenwich.

Conjunctions, configurations, phenomena of satellites, phenomena generally.

Transit of Zero Meridian for physical ephemeris of Jupiter.

In these cases an alteration of 12 hours is necessary: the only complication introduced is in the case of an occultation visible at Greenwich. When the occultation is in progress at midnight, a double date in the margin will be necessary.

MISCELLANEOUS.

The Preface would call attention to the breach of continuity, and state that, while before the change time reckoned from noon was described as Greenwich Mean Time (G.M.T.), after the change time reckoned from midnight would be described as Greenwich Time (G.T.). The absence of M. would serve to call attention to the change.

Midnight would, throughout the *Almanac*, be taken to mean the midnight at the end of the day (this is in accord with common usage). This would be stated in the Preface.

The explanations (*e.g.* those on pp. 541, 543, on conversion from Mean to Sidereal Time) would need some modification.

When the phrase Jan. 0.0 occurs (chiefly in quotations from Astronomical Tables, *e.g.* on p. 565), it would be replaced by Jan. 0 noon.

The places of planets would continue to be given for Noon, there being no reason for a change in this respect, which would in fact be inconvenient, since their Heliocentric places for Noon have already been published up to the year 1940.

It would appear from this report that the necessary alterations in the Astronomical Ephemerides are not very numerous, and could be readily made if the change is considered desirable.

The Council would point out that, from the Report of the Conference on Time-keeping at Sea, it appears that the change would be of considerable advantage to seamen. It is also to be noted that this change will be introduced into the *Extrait à l'usage des Marins* of the Connaissance des Temps from 1920.

In pursuance of the request of the Admiralty, the Council is making inquiries as to the opinions of Astronomical Societies, Superintendents of Almanacs, Directors of Observatories, and other representative Astronomers in the allied and neutral countries as to the desirability of the proposed change.

They would welcome an expression of your views.

INFORMATION REGARDING SMALL PLANETS.

Since about 1913, the Observatory of Marseilles has distributed a limited number of ephemerides of small planets, calculated in large part by Mr. Louis Fabry, assisted by Messrs. Paul Maitre and Henri Blondel, and also circulars giving interesting news about small planets and comets. Recently the Academy of Sciences has recognized this work and has given such assistance that now these publications will be distributed to all observatories and institutions interested. When a sufficient number has accumulated, they will be issued in the "*Journal des Observateurs.*"

The first 23 ephemerides are for 217 Eudore, 380 Siegena, 22 Calliope, 308 Polyxo, 378 Holmia, 859, 511 Davida, 137 Dejanire, 310 Marguerite, 184 Deiopee, 15 Eunomia, 31 Euphrosyne, 162 Laurentia, 521 Prixia, 305 Gordonia, 75 Eurydice, 498 Tokio, 409 Aspasia, 377 Campania, 214 Aschera. The first 7 circulars contain observations by Comas Sola, of Barcelona; Schaumasse, of Nice; Millesovich, of the Roman College, and Sy, of Algiers.

The director of the Marseilles Observatory, Mr. Henry Bourget, and his staff deserve the thanks of the astronomical world for these valuable contributions, produced when their noble country is suffering such unmerited sorrows.

AURORA OF APRIL 5, 1918.

References to this aurora are to be found in this issue in the short article by Mr. Hassard (p. 214), and in the notes from the Meteorological Service (p 236). Other reports have been received, and I give the following:—

Mr. Andrew Elvins, 33 Dorval Road, Toronto (8 p.m.).

The sky to the south was filled with mist which seemed to be luminous. It passed northward and appeared darker when it crossed my window, which faces east. The mist looked like a dark cloud, behind which the aurora lit up the border of the cloud; streamers of light flashed up to the zenith, and then died down again.

Dr. A. A. Hibner, Ogdensburg, N. Y.

The auroral lights were thrilling in brilliance. They began before 9 o'clock and lasted until after midnight. It was the most gorgeous display

ever witnessed by the writer. The lights drifted across the sky like great dense clouds of a terrific cyclone. Streamers were absent, but there was a wave-like motion of ribbon sheets floating across the sky at an altitude of about 60°. The whole northern hemisphere seemed to be disturbed.

Mr. Elvins, who will be 95 on May 5, 1918, has sent the present writer an account, taken from a newspaper of many years ago, of the wonderful dark day experienced in New England on the 19th of May, 1780. The previous winter had been exceptionally severe, with unprecedented falls of snow and low temperatures, and there were numerous auroral exhibitions of exceptional brilliance. Mr. Elvins thinks our past season comparable to this. On the date mentioned, for several hours before and after noon the sky was so dark that candles had to be lighted. The reason for this phenomenon has never been discovered.

ASSISTANT CHIEF ASTRONOMER.

Mr. Robert Meldrum Stewart, of the Dominion Observatory, Ottawa, has been appointed Assistant Chief Astronomer. Mr. Stewart was a distinguished student in mathematics and physics at the University of Toronto, and was given the degree of B.A. in 1902 and of M.A. in 1903. Soon after this, when the newly established observatory began its work, Mr. Stewart was chosen as one of its staff. His first task was the installation of a system of clocks for keeping accurate time and distributing it throughout the government buildings. The system which is in operation has few, if any, equals in the world. Mr. Stewart's main work now is the determination of star positions by means of the meridian circle. This is the least spectacular and most arduous of all the branches of astronomy, and yet it supplies the very foundation of our astronomical structure. All will wish Mr. Stewart continued and abundant success.

THE 72-INCH MIRROR COMPLETED.

At last the great 72-inch mirror for the reflecting telescope of the Dominion Astrophysical Observatory, Victoria, B.C., has been

completed. It was shipped from Pittsburgh on April 18 and before this note is seen in print it will probably be at its destination on Observatory Hill. A full account of the final stages in preparing the instrument for work will appear in a later number.

WHAT IS A "SIDERAIL" CLOCK?

The following bit of news is taken from a Toronto daily which every week prints mistakes found in other papers:—

CAN'T MOVE THIS CLOCK.

All the clocks at the Observatory except one were moved ahead one hour at one o'clock on Saturday, in accordance with the daylight saving law. The one that was not moved on is the siderail clock, whose time is regulated by the stars.

C. A. C.

PLATE IV.

March 23, 9 p.m. April 4, 11 p.m. April 3. 8 p.m.

DRAWINGS OF MARS BY H. WESTOBY, GUELPH, ONT., WITH 6-INCH REFRACTOR, POWER 220

PHOTOGRAPH OF AURORA BOREALIS, MARCH 7-8, 1918

Taken by C. Störmer at Bygdö, Christiania, Norway, March 8, 2 a.m.

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